Effects of Sex, Body Condition and Acclimatizing on the Response to Heat Challenge in Broilers.

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Abbreviated title: Factors of response to heat challenge

Abstract

An experiment was designed to evaluate the respective effects of sex and body condition (Heavy, Light) and their interaction with acclimatizing. A total of 64 broilers were used, with 32 males and 32 females including 16 heavy (average 2096g at day 36) and 16 light (average 1632g at day 36) animals within each sex. From Day 36 to Day 40, half of the animals were raised in hot environment (TA = 31.5°C during day) and half in temperate environment (TA=25.1°C during day). In day 42, there was a heat challenge during which all the animals were all submitted to high ambient temperature (TA=35.0°C). Parameters recorded included body temperature (BT, °C) and hyperventilation rate (HV, Insp/min). During heat challenge, the effect of the previous exposure to climate was significant, with a lower BT (43.14°C vs 43.74°C, $p<0.01$) and NH (140.5insp/min vs 150.5insp/min, $p<0.05$) of animals from hot environment. The effect of body condition was not significant whereas sex was significant (BT: 43.73°C vs 43.19°C, $p<0.05$ and NH: 132.5insp/min vs 149.5 insp/min, $p<0.05$ for males and females respectively). During heat stress, 18 animals died (14 non acclimatized and 4 acclimatized). The analysis of the relationship of death status with other parameters showed that effect of acclimatizing and sex on mortality were significant ($p<0.05$) whereas body condition was not significant.

Keywords: Broiler, heat, acclimatizing, body temperature, mortality

Introduction

Heat stress is a major problem for broiler production in hot countries. While chronic exposure to heat results in reduced growth performance (Teeter *et al*., 1985), acute heat stress can lead to high mortality levels, especially during the last week of rearing period (De Basilio *et al.*, 2001). Mortality has important economical consequences since the animal has already consumed most of its feed.

Several studies have shown that reaction to heat stress was linked to sex, body weight, or genetic strain of the animals (De Basilio, 2010). The acclimatizing of animals has been studied, at early age (early thermal conditioning, e.g. Arjona *et al.* 1988, Yahav and Mcmurty, 2001) or later during rearing period (May *et al.*, 1987, Jordan, 1996), with a significant effect on heat stress and – although inconstant – on mortality. This experiment was designed to evaluate the respective effects of sex and body condition (Heavy, Light) and their interaction with acclimatizing at later ages.

Materials and methods

Animals and management

A total of 196 ROSS x ROSS broilers was used in the experiment, and raised on floor until age 35 days, at standard management conditions (TA controller = 34 °C a 1 days reduced a 28 °C 7 days, TA=26±4°C from 7 to 35d). At day 36, 32 males and 32 females were kept: Within each sex, the 16 lighter animals and the 16 heavier animals were selected. This resulted in the classes described in table 1. During days 36 to 41, half of the animals (acclimatized) were submitted to high ambient temperatures during the day (TA=31.5°C on average), while the other half (non acclimatized) were kept in temperate conditions (25.1°C on average). At day 42, all animals were exposed to a heat challenge: the ambient temperature was raised at 35.0°C from 10:00am to 3:00pm

Table 1. Body weight, BT and HV of animals at beginning of experiment (day 36) according to sex and body condition.

		Females		Males	
		Light	Heavy	Light	Heavy
Body weight (g)	**Average**	1531 a	1982 c	1739 b	2201 d
	min	*1220*	*1815*	*1501*	*2110*
	max	*1620*	*2290*	*1860*	*2370*
Body Temperature (°C)	**Average**	41.36 a	41.54 a	41.53 a	41.56 a
Hyperventilation (insp./min)	**Average**	141 a	124 a	133 a	125 a

Measurements

Body weight was measured on all animals at day 36 and before the heat challenge at day 42. Body temperature (BT (°C) measured by a rectal probe) and level of hyperventilation (HV (insp./min) measured by measuring time for 15 consecutive inspirations) were recorded at day 36 and during heat challenge at day 42. During heat challenge, 18 animals died and this information was recorded to allow a retrospective study.

Results

Body weight, BT and HV at beginning of experiment are presented in Table 1. Logically, BW was significantly different at day 36. In contrast BT and HV did not differ significantly.

During heat challenge, the effects of acclimatizing and sex were significant on both BT and HV (Table2).

Table 2. Analysis of variance of BT and HV according to acclimatizing, sex and body conditions of broilers during heat stress.

Acclimatization (A)	Sex (S)	Body condition (B)	BT		HV	
Non acclimatized	**Male**	**Heavy**	43.74	ab	144.5	a
		Light	44.56	a	140.4	a
	Female	**Heavy**	43.53	ab	158.9	a
		Light	43.25	ab	154.2	a
Acclimatized	**Male**	**Heavy**	43.54	ab	137.9	a
		Light	43.08	b	137.1	a
	Female	**Heavy**	43.21	ab	140.6	a
		Light	42.78	b	144.1	a
SEM			*0.12*		*2.3*	
Effects	**p =**	**A**	0.008		0.035	
		S	0.019		0.037	
		B	0.688		0.731	
		A x S	0.323		0.301	
		A x B	0.110		0.517	
		S x B	0.238		0.837	
		A x S x B	0.213		0.781	

a, b: different letters in column indicate a significant difference between groups (p=0.05)

Animal raised in a temperate environment had a BT and NH of 43.74°C and 150insp/min respectively, while these figures were 43.14°C and 140insp/min for acclimatized animals. In both environments, females had lower BT and higher HV than males. These results confirm the trends mentioned in the Perez *et al.*, (2006) where equally minor BT in the females and major levels of hyperventilation. In contrast, the effect of body weight, irrespective of sex, was not significant. No significant interactions existed between the 3 factors studied.

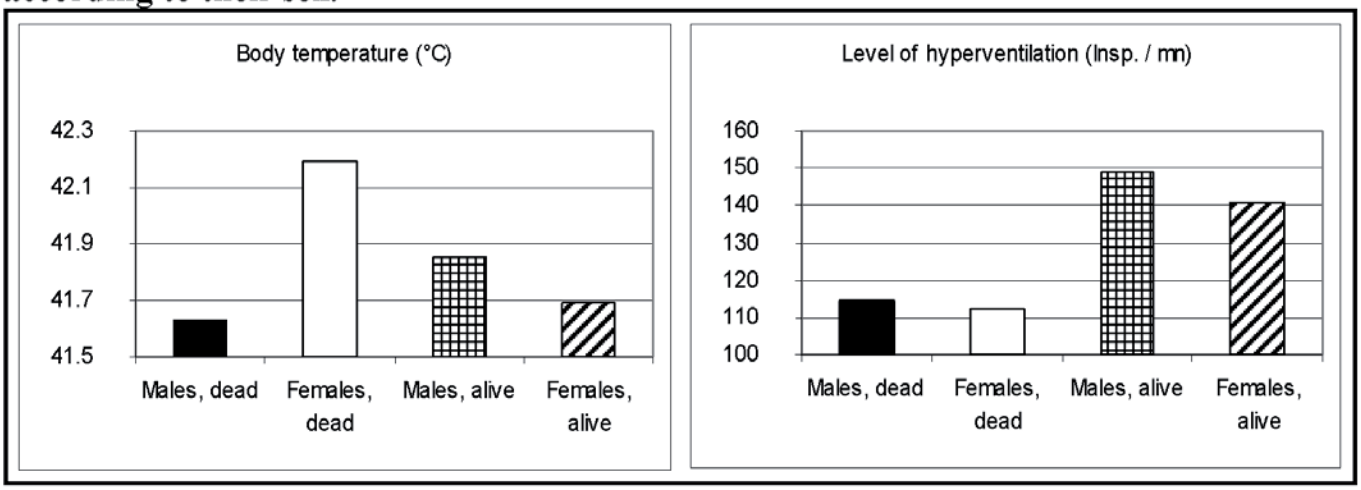
The factors associated with death (De Basilio *et al.*, 2003), were studied by logistic regression of the survival on heat challenge (Table 3). Acclimatizing and sex had a significant effect on the probability of death, with animals acclimatized to heat (odd ratio = 12.5) and females (odd ratio = 4.5) having less probability to die during heat challenge. The effect of body condition was not significant (p=0.23). The BT measured at day 36, i.e. before the experiment, was not significant in the logistic regression.

Figure 1 shows the BT and HV of dead *vs* alive animals. HV was significantly higher in animals which survived than in those which were to die. No general trend was observed on BT, with only dead females having a higher BT than other categories.

Table 3. Logistic regression for survival during heat stress.

Source	DF	Value	STD	Khi²	p=	Odd ratio
Constant	1	44.33	56.93	0.58	0.44	
BT at day 36	1	- 1.04	1.37	0.58	0.45	-
Acclimatation temperate vs hot	1	2.52	1.10	5.26	0.02	12.5
Sex F vs M	1	1.50	0.68	4.86	0.03	4.5
Body condition light vs heavy	1	0.78	0.65	1.44	0.23	2.2

Figure 1. BT and HV of animals which died or survived during heat challenge, according to their sex.



Discussion

Acclimatising to high ambient temperatures during 1 week had significant effects on resistance to a heat stress. Both BT and HV were significantly reduced during heat challenge in acclimatized animals. The effect on mortality was also important since 5 animals died in acclimatized group vs 13 animals in non-acclimatized group. This is in accordance with Yahav and Hurwitz. (1996). The effect of sex on heat resistance is well known (May and LOTT, 2001). In this case it was highly significant, with females showing lower BT during heat challenge, and higher HV in non-acclimatized group.

An interesting point is the absence of significance of body condition within each sex. It is often hypothesized that higher body weight lowers resistance to heat (Cooper and Washburn, 1998). This observation is sometimes linked to the fact that females are lighter and die less. Also there can be a confusion between the effects of chronic heat (where heavy animals have indeed a higher BT and acute heat stress as studied here. Indeed light males, although lighter than heavy females, had a higher BT (43.82 *vs* 43.37°C) and a lower HV (139 *vs* 149), showing that the differences were linked to sex rather that body weight.

There was no significant effect of BT at day 36 on the death probability of animal, showing that in this experiment the main factor was the acclimatizing of the animals and not an individual difference in basal BT.

Conclusion

The analysis of the relationship of death status with other parameters showed that effect of acclimatizing and sex on mortality were significant ($p<0.05$) whereas body condition was not significant.

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